Third United Nations International Conference on the Peaceful Uses of Atomic Energy

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Abstract

HEAT TRANSFER IN LIQUID-METAL-COOLED REACTOR ELEMENTS

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In spite of some progress in theory the experimental studies of heat rransfer to liquid metal remain for the present the main research methods.

This report gives new data on heat transfer to liquid metals obtained recently with the development of liquid-metal-cooled reactors.

As a result of temperature distribution measurements in the flow of sodium, sodium-potassium alloy, lithium, mercury, a general equation for temperature distribution in different liquid metals was obtained, addy diffusivity heat transfer coefficients in round tubes were determined and also some statistical characteristics of turbulent flow were evaluted.

In studying free convection effect it was noted that the well known McAdams rule could not be applied.

In this report the problems of heat transfer in slab fuel elements are considered. These elements are characterized by enlarged heat exchange surface. Analytical calculations and experimental studies revealed some specific features of heat transfer in rectangular cross section ducts. Data for extimation of channel geometry, fuel layer and shell thickness and their thermal conductivity, etc. were obtained.

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The problems of heat transfer to liquid metals in parallel flow through bundles of circular rods are considered, empirical equations for circumferential temperature distribution calculation of such fuel elements are given. The temperature distribution in bundles of fuel elements is shown to depend also on their properties (thermal conductivity, sizes, etc.).

It was proved that equivalent hydraulic diameter did not apply to generalization of heat transfer coefficient values for liquid metals in complicated cross-section ducts.

Circular fuei elements are classified according to their thermal properties and the possibility of thermal simulation under laboratory conditions. Methods of circular fuel element thermal simulation are described.

Comparison of experimental results for heat transfer to liquid metals and water in parallel flow through bundles of circular roods is given . The use of equivalent hydraulic diameter as a typical size of bundles through which water or some other ordinary liquid flow is noted to be not crear enough.

An approximate method of temperature distribution calculation for circular element bundle based on the analysis of uniform velocity liquid flow (slug flow) is considered. In some cases these results give a sufficiently correct physical picture.

This report presents the results of the investigation of average heat transfer coefficients in shell-and-tube heat exchangers of "liquid metal-liquid metal" type with different lattice pitches and with different lengths of the tubes. It is shown that average heat transfer coefficients in heat exchangers and in fuel element bundles must differ from one another.

Investigation of pressure drop in fuel element bundles

allowed to reveal some inherent features of these systems (e.g. significant decrease of friction factors in close-packed bundles, etc.).

As a result of sufficient number of heat transfer to liquid metals experiments with cross flow through tube bundles average heat transfer coefficients may be calculated. However pulsation amplitudes of heat-exchange surface temperature that amount 40 to 60% of average temperature drive excite appreheusion as to reliability of durable work of some of these systems.

The results of experimental heat transfer studies when changing aggregate conditions of liquid metals are given. Investigations of heat transfer coefficients and burnout heat flux rate in the case of bailing natrium under free convection conditions revealed some inherent features of liquid metal boiling (pressure pulrations, different boiling conditions, etc.)

Condensation processes of potassium vapours were studied on flat vertical wall. Visual observations and photographs showed some peculiarities of substitution of droplet condensation by film one.

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Abstract

THEORETICAL MODEL OF TURBULENT DIFFUSIVITY IN THREE - DIMENSIONAL LIQUID FLOW

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Three-dimensional model of turbulent diffusivity is formulated; this model permits to approximate all nine components of tensor of turbulent stress and three components of turbulent heat flow involved in original equations of dynamics for the turbulent flows.

The use of the developed model of turbulent diffusivity permits to formulate mathematically and solve different hydrodunamic and heat transfer problems for liquid flows in ducts of arbitrary form.

The developed theoretical model of turbulent diffusivity has been tested on calculated velocity and temperature fields in liquid flows in round tube.

Obtained values of velocity and temperature fields, resistance and number Nu factors give a good agreement with the available experimental results.

Further the results of velocity and temperature fields calculation are given for turbulent flow of liquid in channels of other modes - in annulus, flat and square channels and rod lattices.

Calculation results of velocity and temperature fields

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for above mentioned channels are compared with the available experimental results.

Sufficient agreement of these results with the experimental data gives ground to believe that the above mentioned theoretical model permits to determine the temperature fields in the fuel elements with its arbitrary construction with sufficient confidence.

In conclusion the possibilities of certain further generalization of theory and calculation procedures for hydrodynamic and heat conditions in reactor cell are given.

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Abstract

REACTOR CONTROL SYSTEMS

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The paper briefly discusses the main design principles of nuclear reactor control systems.

The requirements to the system design: maximum simplicity, channel duplicating, use of reliable elements (transistors, magnetic amplifiers, non-contact elements). The paper describes reactor monitoring, beginning from the subcritical condition, by means of instruments operating from the current ionisation chambers and gives the characteristics of the instruments which provide the means for the measurement of the period and power on a logarithmic and linear scale.

Two systems of automatic power level control are described, one exponential with a preset period, and the other linear. An emphasis is made on the advantages of one power controller, common for the entire system, with automatic and manual level correctors. The paper describes rod interelation which enables automation of the processes requirdng introduction of reactivity and compensation for the reactivity deviations which exceed the effectiveness of one rod.

The paper goes on to discuss the safety provisions, alarm system and emergency shut-down systems, the relation between the circumstances which require reactor shut-down and the means for quenching the reaction; specific features of the system for the power level overshoot control are noted.

The paper shows the advantages of the actuator control schemes using transistorised elements as compared with the control schemes using relays and contactors.

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Abstract

HIGH-PRESSURE REACTOR VESSELS

V.V.Stekolnikov, A.A.Khokhlachov et al.

The high-pressure vessels water-water reactors built in the USSR have been designed so as to ensure their full industrial manufacture and the possibility of shipment over the USSR railways.

The designers had to solve many problems (including metallurgical, engineering, welding, the problem of strength, etc) and to carry out research to determine the structural features which would innance the vessel reliability.

The paper discusses the requirements to the materials of the vessel for a large water-cooled water-moderated reactor, problems involved in the choice of the materials, the corrosion stability of the materials, etc.

A great deal of attention is devoted to the investigation of the vessel in a stressed condition, investigation of the material strength at repeated static loading under conditions which approximate the actual working conditions, evaluation of the marginal strength and strength tests on full-size and scale models. Choice of the seals, and seal performance test on full-size and scale models are also discussed.

The paper touches upon the vessel performance under alternating conditions, since large thicknesses and non-uniform heating of the vessel by the coolant result in considerable stresses caused by the difference of the temperature in various elements of the vessel. The description of the approaches to the solution of these problems is given, including the problem of the serviceability of electrically welded butt joints from steels with different coefficients of linear expansion.

The correct solution of the engineering problems determines, to a large degree, the performance, life and reliability of the vessel. Therefore, the paper deals with some of the key engineering problems and with the problems of the quality control.

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